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INVESTIGATING THE FUNDAMENTALS OF THE THIRD GENERATION WARGAME: WARGAMING, A COURSE FOR FUTURE DEVELOPMENT

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14. ABSTRACT
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Abstract

This effort investigated methods to provide superior decision support primarily for dynamic planning and execution in support of both Crisis Action Plans and Deliberate Planning. This was accomplished by evaluating current Air Force wargaming methods and looking at ways to improve them. Issues with current wargaming methods were identified while methods for improving them were developed, leading to improved methods for future wargames and combat mission planning.

Acknowledgements

1.0 Summary

This final technical report describes the results of the "Next Generation Wargaming" in-house investigation. The goal was to develop methods to improve the fidelity and effectiveness of USAF wargames to provide superior decision support for dynamic planning and execution of military campaigns. This was achieved by initially evaluating current Air Force wargaming methods and identifying their strengths and weaknesses, identifying new methods and approaches for improving military wargames via study of current state-of-the-art technology, and developing approach for implementation of new methods. The commercial wargame industry was surveyed for relevant applicable capabilities. Several short term projects were identified and implemented to rapidly improve available wargaming capabilities.

2.0 Introduction

The goal of the Third Generation Wargame Project was to improve the fidelity and effectiveness of wargames providing decision support for dynamic planning and execution. To accomplish this goal, current Air Force wargaming methods were evaluated for ways to improve their benefit to the warfighter. This was done by identifying the most effective strategies to improve wargaming and campaign planning. An important conclusion from this effort is the need for a C4I adjudicator at USAF Title X wargames and other AF wargames to enable C4I to get the necessary consideration it needs for realistically modeling campaign scenarios.   This effort began in 2001 with a general study of USAF use of wargames as influence on education, tactics, techniques and procedures. We will provide a brief background of wargames, the history, use and types of wargaming in USAF.

3.0 Background

The term "wargame" is a translation of the German term *Kriegsspiel* used by the Prussians who were the primary early adopters of second generation wargames. As for formal definitions, Webster defines *wargame* as a "simulated battle in military training maneuvers." [1]. While the *Official Dictionary of Military Terms* defines *wargame* as "a simulation by whatever means of a military operation involving two or more opposing forces, using rules, data, and procedures designed to depict an actual or assumed real-life situation." [2] For purposes of this study we used military terms definition. However, some seem to confuse the terms *modeling, simulation,* and *wargaming* as if they were identical, but they are distinct elements of wargaming.

Models are proportional representations of reality. A sketch is not a model, but a blueprint is. Models vary in abstraction; a physical model of an aircraft, a blueprint of that aircraft, and a mathematical equation representing that aircraft's flight characteristics are all models of that aircraft.

Simulations are proportional representations of reality over time. For example, a small wing that is proportional to a full-sized wing is a model. Put that wing in a wind tunnel and measure the effect of various wind speeds and you have a simulation.

Wargames are simulations of an armed conflict against a thinking opponent. Wargames can be thought of in terms of first, second and third generations. The first generation, called Mind versus Mind, had several characteristics: symmetric forces, abstract units, strategic focus, and single unit moves. Common examples are: Chess and Go. The second generation, called Force versus Force, had several related characteristics: symmetric forces, differentiated combat units, attrition, and single side moves. Common examples are: Risk and Stratego. The third generation, called System versus System, have an effects based focus and asynchronous moves. An example is a real time strategy game. It will have asymmetric engagements, with forces including "non-combat" capabilities and vulnerabilities, such as embedded reporters. While there are no good examples, most components have been individually utilized previously in advanced Second Generation games. It is the third generation that we focused our efforts on. Within the broad context of wargames there are also several categories as discussed in next section

3.1 Types of Wargames

Seminar games, sometimes known as BOGSAT (Bunch Of Guys Sitting Around a Table) are often used in situations where complex, incompletely understood interactions are being evaluated (politics, diplomacy, news media…). Major examples of seminar games are the Title X wargames (Global, Army After Next, United Engagement, the Schriever Space Game) run for the Chiefs of Staff and required by act of Congress.

Massive Multiplayer Online Game {MMOG} (examples: America's Army, World of Warcraft, Planetside). These are an effective way of getting lots of humans to work both together and in opposition without the huge TDY expenses of bringing them all to the same place. This concept involves extensive connection and access issues.

Real Time Strategy {RTS} (examples: Starcraft, Star Wars Rebellion, Hearts of Iron). These commercial wargames are not necessarily strategy, but definitely real time as the clock is always running. This game technique often uses finite time steps. RTS games are implementation examples of the asynchronous turns needed for third generation wargames.

First Person Shooters {FPS} (examples: F-16, Strike Fighter, Halo, Quake, Doom, Half-Life) are an extremely popular commercial application type, with the player often running (or flying) around in a virtual environment in the persona of a shooter. These wargames can often run as a Multiplayer Online Game (MOG). These are examples of where the commercial market has implemented almost all the hard work necessary for a level of wargame (tactical) of practical use to the military.

Midway between Tactical and Strategic games are operational level games. It was found that these tend to be the most demanding in terms of design. Games designers must utilize the interactions of the various systems in an appropriate manner to achieve effects at operational level. Fortunately there is a dedicated commercial niche market that produces operational wargames for a demanding audience of primarily professional military, historians, and other college educated professionals. Unfortunately, there are currently few good operational airpower wargames on the market.

Hexagon (hex) based wargames developed first in the paper print wargame industry as a method of speeding and regularizing movement and combat in the designated environment, and minimizing diagonal movement error. Although this is a useful formalism for enforcing the concept of span of control, it imposes a specific level of granularity on the players, which must be carefully designed in the wargame.

The Free Form (Miniatures/ Sand Table) wargame is the original Kriegsspiel approach, heavily overtaken by hex wargames two decades ago, but now making a strong comeback. In computer based wargames this approach often employs a pixel based environment mapping.

4.0   Survey of Current USAF Wargames

In order to learn more about the current USAF wargaming approaches and methodologies, we actively participated in the USAF Title X wargames: Global Engagement IV, Global Engagement V, United Engagement 06, and Futures 05. AFRL/RI also observed the Air Command and Staff College (ACSC) capstone wargame AEROSPACEX 05 and the Squadron Officer College's wargame (Air Gap) to evaluate and elicit a better understanding of the wargames used to train future campaign planners. These games represent a major portion of the USAF use of wargaming for experimentation and education.

As a player and observer, AFRL/RI provided input for future improvements, in areas such as adjudication of combat results and organization of the wargame. In particular there was a noticeable lack of adjudication of the impacts that C4I technologies bring to wargame. While final debriefs described the need for such capabilities, there were no functional participation during these wargames. For example, no adjudicators were assigned to C4I at any of those USAF Title X wargames. If C4I isn't adjudicated, it has little impact on the wargame or the Chief of Staff USAF who is the ultimate recipient of the wargame report. To break into the adjudication sequence and play, a feasible methodology to embedded C4I into the adjudication sequence needs to be developed. It should provide the appropriate tools to assist the players and adjudicators.

Another major portion of the USAF use of wargaming is evaluation of Courses of Action (COAs) generated for campaign plans, both deliberate plans and Crisis Action Plans. During the course of this effort, AFRL/RI presented the Third Generation Wargame concept [3] to Checkmate, which is in charge of strategic and crisis action planning for the Air Force, A5 and A9 at the Pentagon, to formulate development strategies and requirements.

4.1 Commercial Wargames Analysis

Commercial wargames were analyzed to determine how they could benefit USAF wargaming efforts in the following ways: the first of these was directly out of the box, the second was with modifications supported by modification communities and software, and third was with minor modifications from interested commercial firms.

AFRL/RI also investigated the technical investment patterns and development of Application Programming Interfaces (APIs) in the commercial world. The intent here was to

identify both what the USAF could leverage from existing products and also to identify proven capabilities that were adaptable to USAF needs.

As the analysis was conducted, the main assumption was that the USAF needs to be able to evaluate their campaign plans in order to win. To accomplish this goal, they need to understand the enemy forces, including strengths and strategies.

Resulting from this analysis, we developed a design framework based on third generation techniques. This concept for a third generation system versus system, rather than mind versus mind or force versus force of the first two generations of wargame [4] and were the impetus for several follow-on efforts.

Briefly, the current design incorporates three interlocking nets of interaction: the C4ISR net (primarily utilizing electronic/electrical communications), the system net (movement of material), and the environment net. The three nets are used to depict the three different ways entities will interact. Each entity is represented on all three nets, be it an oil refinery, a bridge, a mechanized infantry battalion, or a police car. Each entity is represented on each net by a modular net specific object.

The results included formulation of strategies for advanced third generation wargames, including presentation and publication of papers on third generation wargames [3, 4, 5]. Based on the complexity and development scope of the third generation wargame (3GWG) [4] and the weakness of the required supporting Intelligent Agent and Critical Actor Modeling technologies [6], focus shifted to more modest objectives in time and resources.

These results and lessons learned provided the impetus to spin off additional projects in advanced intelligent agents [6], wargame construction toolkits [6], alternative User Interfaces for wargames [8], and also inspired or supported the Cyber Kinetic Warfare Exercise (CAAJED), a COTS operational airpower wargame (Modern Air Power) currently utilized by the Air and Space Basic Course (ASBC) and the Squadron Officer College (SOC).

4.2 Lessons Learned

One of the cultural difficulties encountered in this project is the lack of an overall organization in the Air Force with the responsibility to improve the Air Force's wargaming capability. Instead there is a broad spectrum of users who spend their limited funds on stove-piped solutions with limited coordination. This limits efficiency, collaboration and reuse.

Another cultural difficulty is the lack of understanding of wargames by some members of the simulations community, affecting the realism of simulations produced.

There is also the need to unify efforts to create universal wargaming development solutions throughout the Air Force.

Often, to keep a very expensive undertaking called a Seminar wargame going, the assessment team will hand out an absurd result so that the wargame can continue to explore various questions. For example, with 1000 warheads inbound, and 120 defensive anti-warhead shots, no warheads hit a target because Red would win and it would be "game over" a third of the way through the wargame. An incident like this engagement should cause several soul-searching questions to be raised; but tends to be lost and never mentioned in the After Action Report, and then is never evaluated.

There are at least two possible improvements to minimize this process glitch. The first is to cut the cost of the seminar games by making them virtual games on the SIPRnet, and second by improving the assessment software so that less human assessment is required.

5.0   Wargames Design Criteria

5.1 The Human Element

The wargamer wants to win. The side he represents in the wargame also intends to win. It is extremely rare for a force to initially engage in war without some idea of how they plan to win. Even then, they will try every which way to win, to adapt, to change, to squirm and to "cheat" in order to win. Software Intelligent Agents don't care about this. Predictable opponents lose quickly, or change and become unpredictable. This is the critical weakness of automated wargames. They only represent the opposing or friendly forces to the point that a human opponent would decide they must change, and only then, if their commanders actually fight from their Command and General Staff textbook. Facing commanders unconstrained by textbook doctrine, such as Rommel, Patton, Quesada or a Kenney using scenario runs controlled by Intelligent Agents would be of dubious value.

If time were available, it would be best to use a human player at the top command level, and who was able to act only when someone at that level would normally react. Identification and enforcement of the Decision Cycle is critical.

5.2 Simulation versus Wargame

Wargames are often disparaged for not having the accuracy of simulations. This is a specious argument. First, simulations provide input data for wargames. Second, simulations can generate several digits of accuracy on how much more accurate gun A is than gun B. But the simulation does not include the impact of the human aiming the gun. The human is at best modeled accurately to a single digit. When you put a raw recruit behind gun A for the first time, those six digits of accuracy go out the window. Therefore, the accuracy of a simulation to predict battlefield performance is, at best, similar to wargames.

5.3 Wargames Stimulate Questions

Wargames are valuable in generating questions to be asked, not to be taken as the answer to a situation. Wargames don't prove anything, but should instead inspire questions about decisions that were made during the game, and evaluations of umpire decisions, and the impacts of any other scenario artifacts.

For example, the Japanese Admiral wargaming the Midway campaign missed a very critical question; why were the American carriers located in that particular location in the wargame? There was a logical reason, and during the actual battle, the real US carriers were actually within 15 nautical miles of the wargamed carriers. The Japanese scout plane historically going to that area had engine problems, and was very late taking off. The astute Admiral,

remembering the wargame lesson, would have diverted a different scout to the critical search pattern; resulting in a very different battle.

5.4 Education and Negative Learning

Wargames are powerful educational tools, helping players comprehend issues related to the complex interactions represented. However, the representation must be reasonably correct or the players will be learning the wrong things (negative learning). This is why carefully planning is valuable for wargames.

5.5 Silver Bullets

Silver bullets are miracle systems that kill everything, nothing can stop them, and nothing can mitigate them. For example: perfect situational awareness from the satellite constellation, 24/7 on thousands of small targets with hundreds of thousands of civilian look-a-likes. However, even though many new weapons have tremendous capabilities, their capabilities need appropriate evaluation by unbiased evaluators.

This problem can be mitigated by keeping the contractor's salespeople out of the games' databases, and using a skeptical AFRL evaluation of the "miracle" system. The enemy will develop countermeasures, even if it's initially only a 10% mitigation. It's also hard for the US to keep a new weapon out of the press, and once it has been used once in the field, someone has probably successfully salvaged one dud weapon and dissected it. Therefore, all new weapons need to be evaluated for defense against countermeasures.

5.6 Non-Adaptive Opponents

In the real battlefield, situations constantly change and people adapt or die. Current Intelligent Agents don't adapt well, but there are several projects working in AFRL to mitigate this automated wargaming issue.

5.7 Constrained Opponents

Many wargames are flawed by not allowing either or both sides enough flexibility to exercise their realistically available options. For example: Red Team Lead to Red team: "We're going to be reasonable actors, and a reasonable actor wouldn't do X". Adolf Hitler, Idi Amin, and Pol Pot may have been reasonable actors to their own way of thinking, but not to an American inside-the-box thinker. This particular deficiency has been occasionally corrected in seminar games by making the team leads specialists in the appropriate culture. This is an important issue to address when planning campaigns in foreign countries with different cultures.

5.8 Target List Opponents

These are opponents in name only, since they exist merely as a list of targets to be serviced. For example, the "wargame" Pacifica is a non-reactive set of targets.

5.9 Opponents Without a Chance

In any scenario worth exercising, both sides should believe that they have a chance of winning the war, or else they would find other ways to resolve their issue. Often, wargame designers set up a Straw-man or punching bag opponent in an experimental or educational wargame; these may be "fun" or uplifting, but are dangerously misleading and don't force questions to be asked. An example would be an opponent who spent the last thirty years stocking up for the big war by buying 30+ year old equipment so he's forced to fight a symmetric war against a thoroughly modern opponent. In one case, there were approximately 250 F-22s and 100 F-35s against 1000 Mig-21s and 200 Mig-25s.

This question must be answered during the game development cycle: how does Red expect to "win" if the 900 pound gorilla shows up for the war? Every single potential opponent out there worth worrying about realistically does have such a plan and is constantly updating it. This issue can be best resolved by better training and applied practice for wargame designers.

5.10 Sanctuaries in Wargames

A common example of poor wargame design comes from the misuse of sanctuaries, such as employing the concept of the continental US (CONUS) as a sanctuary. In essence, Blue is allowed to throw rocks into the Red homeland from inside CONUS. But Red isn't allowed to try to destroy the rock throwers in the US since "that would be escalatory" or "terrorism". In this case the sanctuary is an unrealistic mechanism and a different wargame design must be employed.

6.0 Commercial Wargame Utility

Commercial wargames are designed for the audience that buys them. The three largest wargame markets are Real Time Strategy (RTS), First Person Shooters (FPS), and Massive Multiplayer Online Games (MMOG). These games tend appeal to the young, and that is where most of the investment money goes also. But a reasonable section of the wargame audience likes to think about what they plan to do within the wargame, and those people tend to be highly educated, with a significant portion of them military professionals. This niche market demands operational and strategic level games of significant fidelity, and there are several game companies that market to that group. It is within that niche market that useful commercial wargames can be found.

6.1 Balancing Ease of Play Versus Level of Accuracy

The more mature audiences are more willing to accept more difficult play in exchange for higher accuracy. Usually this is a direct trade-off, but some designers do better at this than others. In a similar manner, for an automated wargame, the designer would be balancing the trade off of less critical detail in exchange for shorter run times.

6.2 Modification Communities

Modification Communities (Mod Communities) are groups that have established ways of developing many more scenarios than provided by the original designers. The software tools are usually provided by the original game maker. Websites, users groups, and FAQ lists are common. Most first class first person shooter games are mod community enabled from the start.

7.0 Conclusion

This effort confirmed the need for a C4I adjudicator to be present at Air Force Title X wargames, and other Air Force wargames. This consistent oversight will enable these issues to receive the attention and input that they need for enabling the wargame to properly address C4I issues as a tool toward campaign planning in wargames.

This effort investigated methods to provide superior decision support primarily for dynamic planning and execution in support of both Crisis Action Plans and Deliberate Planning. This was accomplished by evaluating current Air Force wargaming methods and looking at ways to improve them. Issues with current wargaming methods were identified while methods for improving them were developed, leading to improved methods for future wargames and combat mission planning.

8.0 Future Developments

8.1 Wargame Construction Tool Set

A wargame construction toolset prototype developed under the auspices of this in-house project allows a GOTS approach to wargame availability with an open source modular design approach. Modest upgrades would make it a useful experimental tool within AFRL and the Professional Military Education arenas. [9]

8.2 Crisis Action Planning and Deliberate Plans

The Third Generation Wargame concept for Crisis Action Planning and Deliberate Plans will require extensive investment if it is pursued further. [4]

8.3 Better Intelligent Agents

Better Intelligent Agents will improve the utility of wargames. The SimBionic IA software developed under the auspices of this in-house project for the graphical representation and definition of IA behavior has significantly improved this situation, and years worth of work can be expended in the future to improve this area. [6]

8.4 Massive Multiplayer Online Game (MMOG) Tools for Title X Games

Using Massive Multiplayer Online Game (MMOG) tools would reduce the automation needs and could significantly improve the human element within the wargames. This technique would allow reasonably accurate, human-in-the-loop C4I experiments to be executed; also available would be Title X games with embedded C4I adjudication. The Information Assurance issues will, however, be a challenge.

8.5 New Wargame Methodology for C4I Wargaming

A pixel level flowing wargame with adjustable time steps (asynchronous moves), and on-the fly modifiable IA behaviors, and easily defined connectivity to pushing the envelope of C4I is a new wargaming methodology.

8.6 Light-weight Crisis Action Planning Tool

There is a distinct need for a light-weight Crisis Action Planning Tool, with reach back capability for more robust analysis, that allows the Joint Forces Command staff to rapidly define the crisis scenario, and set up multiple courses of action (COAs); preferably while including other government agency plans and incorporating the capability to assimilate non-government organization (NGO) projected planning. Then, it is important to generate critical nodes and monitor the campaign, watching for deviations (adaptations) as they occur, into order to rapidly counter them and predict when the next adaptations would occur. Ideally, this should progress to the point of predicting adaptations so that the countermeasures will already be in place. [10, 11]

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Appendix A: History of Wargames

The history of wargames has been documented by Col Matthew Caffrey, Jr (Ret.) an AFRL IF Senior Reservist during a portion of this in-house project. His short history [3] has been published in the Aerospace Power Journal. This section hits some highlights from that document.

Wargames emerged among the rulers of all early civilizations. Cultures separated by thousands of miles and hundreds of years felt the same necessity to prepare their future rulers to outthink other rulers. Although games like "Go" and chess are quite abstract, they do teach "down-board" thinking; anticipating the consequences of one's possible moves and the opponent's possible responses, an essential skill in the deadly game of war.

Modern wargames began to take shape in the early 1800's in Prussia, developing a system that any modern miniatures wargamer would recognize. This sand table (and later map) system was initially used for educating the rapidly expanding Prussian officer corps, followed by more critical usage as a planning aide for developing what we would know now as contingency plans.

In the mid 1800s Prussia achieved renown for smacking around the largest armies of Europe. Not surprisingly, the rest of the world started copying Prussia's (now Germany's) wargaming methods. The pattern usually went like this: A young officer would translate German manuals, often improving some aspect in the process. He would meet initial opposition, but in time the use of wargames became institutionalized.

In the US, it was a Major Livermore who sought official acceptance of wargaming, but he was blocked by Gen William T. Sherman, the US Army's chief of staff at that time. He disapproved Major Livermore's proposals, stating that wargames depict men as if they were blocks of wood rather than human beings who are seized by fear and sustained by leadership. His basic objection was that Major Livermore's wargame, like all up to that time, only depicted attrition with units fighting to the last man. Sherman knew better.

In 1895, a wargame played a critical role in convincing Congress to fund the Cape Cod Canal. This was the first documented time a wargame impacted the national budget.

In 1905, a British wargame showed France being defeated by a plan very similar to Germany's actual war plan, because the British Expeditionary Force could not get to the battle in time. This spurred the British to take several actions leading to faster mustering and transit across the English Channel, which in 1914 culminated in the Miracle on the Marne.

Some wargames are ignored at peril. In 1914 Russia, the commanders of Russia's two most modern armies played a wargame that they reenacted later that fall in reality, with the same results; the battle of Tannenberg (where a significantly inferior German force destroyed one Russian army and defeated the other). In both cases the Russian armies had split up while going around a sector of lakes, allowing the Germans to engage the armies individually.

Prior to World War II, the German navy developed submarine wolfpack tactics without a single submarine in its inventory by wargaming using torpedo boats in their wargames. At approximately the same time, the German Army developed the Blitzkrieg without a single tank or combat aircraft by using wargames with trucks and bicycle delivered "bombs".

During the same time period, the US Navy used wargames to develop aircraft carrier designs, it's carrier deck staging process and combat air patrol tactics. They employed a wargame that used tricycles, lampshades and a large hangar to develop those combat air patrol tactics. With inferior pilot training and aircraft, the inferior-in-strength US Navy was still able to seize the initiative from the Japanese Navy at Midway due in part to the strengths conferred by those wargame developments.

The US Marines developed amphibious warfare tactics using a series of wargames; even though the general military consensus was that amphibious warfare was impossible when faced with modern weapons.

In the 60s the US Army wargamed the airmobile division, and implemented it in the Vietnam war, while the USAF lost the Skybolt guided missile program because there was a lack of wargaming to convince the Secretary of Defense of its value.

In the Operation Desert Storm era, various automated wargames utilized by the government were fairly unanimous in predicting 30,000-40,000 causalities for the Allies, just to recapture Kuwait, and the political analysts said that that was all the American public could handle. On the other hand, commercial wargamers predicted 2,000 -3,000 causalities, they remembered General Sherman and his objection to blocks of wood. In reality, the casualties were even lower than predicted by the commercial wargamers. The commercial wargamers had included what the official wargames left out, morale and training. So the US went into combat with homeland emergency rooms seriously short staffed with many EMTs being reservists, totally unprepared for the volume of POWs we would have to deal with, and stopped when the destruction of the Iraqi army was at hand. We also never ran a political/ military (pol-mil) wargame about what would happen inside Iraq when the army was no longer available to repress everyone.

Verification and Validation to Historical Situations

It is important to test wargame algorithms and processes against similar historical situations. The wargame design needs to be able to least approximate an historic outcome, before it can be expected to be useful for current developments.

Most government wargames cannot emulate the Blitzkrieg, which first occurred two-thirds of a century past. Superior Command and Control was one of the implemented capabilities involved in that Revolution in Military Affairs (RMA). Also, superior Command and Control is why modern US DoD wargaming has the war taking longer and being bloodier than the reality; leaving policy makers and commanders poorly positioned to deal with their succ